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SCIENCE

FRIDAY, SEPTEMBER 25, 1914

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ADDRESS OF THE PRESIDENT TO THE GEOGRAPHICAL SECTION OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE¹

MAN AS A GEOGRAPHICAL AGENCY

IN an inaugural address to the Royal Scottish Geographical Society on Geography and Statecraft Lord Milner said: "If I have no right to call myself a geographer, I am at least a firm believer in the value of geographical studies." I wish to echo these words. I have no expert geographical knowledge, and am wholly unversed in science, but I am emboldened to try and say a few words because of my profound belief in the value of geographical studies. I believe in their value partly on general grounds, and largely because a study of the British empire leads an Englishman, whether born in England or in Australia, to the inevitable conclusion that statecraft in the past would have been better, if there had been more accurate knowledge of geography. This statement might be illustrated by various anecdotes, some true, not a few apocryphal; but anecdotes do not lend themselves to the advancement of science. I am encouraged, too, to speak because the field of geography is more open to the man in the street than are the sciences more strictly so-called. It is a *graphy*, not a *logy*. Geology is the science of the earth. Geography is a description of the face of the earth and of what is on or under it, a series of pictures with appropriate letterpress and with more or less appropriate morals to adorn the tale. The man in the street may talk affably and even intelligently about the face of the earth.

MSS. intended for publication and books, etc., intended for review should be sent to Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

¹ Australia, 1914.

Taking the earth as it is, geographical discovery has well-nigh reached its limit. The truth, in the words of Addison's hymn, is now "spread from Pole to Pole," and recent exploration at the South Pole, with its tale of heroism, will have specially appealed to the citizens of this southern land. Coasts are in most cases accurately known. The age of Cook and Flinders is past. Interiors are more or less known. In Africa there is no more room for Livingstones, Spekes, Burtons and Stanleys. In Australia Sir John Forrest is an honored survival of the exploring age—the age of McDouall Stuart and other heroes of Australian discovery. The old map-makers, in Swift's well-known lines, "o'er unhabitable downs placed elephants for want of towns." Towns have now taken the place of elephants and of kangaroos. Much, no doubt, still remains to be done. The known will be made far better known; maps will be rectified; many great inland tracts in Australia and elsewhere will be, as they are now being, scientifically surveyed; corners of the earth only penetrated now will be swept and garnished. But as we stand to-day, broadly speaking, there are few more lands and seas to conquer. Discovery pure and simple is passing away.

But meanwhile there is one side of geography which is coming more and more to the front, bringing it more than ever within the scope of the British Association for the Advancement of Science. "Man is the ultimate term in the geographical problem," said Dr. Scott Keltie some years since at the meeting at Toronto. "Geography is a description of the earth as it is, in relation to man," said Sir Clements Markham, long President of the Royal Geographical Society. Geography, I venture to think, is becoming more and more a description of the earth as it is and as it will be under the working hand of man. It is

becoming intensive rather than extensive. Geographers have to record, and will more and more have to record, how far man has changed and is changing the face of the earth, to try and predict how far he will change it in the coming centuries. The face of the earth has been unveiled by man. Will the earth save her face in the years before us, and, if she saves her face, will it be taken at face value? How far, for instance, will lines of latitude and longitude continue to have any practical meaning?

Man includes the ordinary man, the settler, the agriculturalist; man includes, too, the extraordinary—the scientific man, the inventor, the engineer. "Man," says a writer on the subject, "is truly a geographical agency," and I ask you to take account of this agency for a few minutes. I do so more especially because one of the chief features of the present day is the rise of the south; and the rise of the south—notably of Australia—is the direct result of human agency, on the one hand transforming the surface of the land, on the other, eliminating distance. The old name of Australia, as we all know, was New Holland. The name was well chosen in view of later history, for while no two parts of the world could be more unlike one another than the little corner of Europe known as Holland, or the Netherlands, and the great Southern Continent, in the one and in the other man has been preeminently a geographical agency.

The writer who used this phrase, "Man is a geographical agency," the American writer, Mr. G. P. Marsh, published his book, "Man and Nature," in 1864, and a new edition, entitled, "The Earth as Modified by Human Action," in 1874. He was mainly concerned with the destructiveness of man in the geographical and climatic changes which he has effected. "Every

plant, every animal," he writes, "is a geographical agency, man a destructive, vegetables and in some cases even wild beasts, restorative powers"; and again: "It is in general true that the intervention of man has hitherto seemed to ensure the final exhaustion, ruin and desolation of every province of nature which he has reduced to his dominion." The more civilized man has become, he tells us, the more he has destroyed. "Purely untutored humanity interferes comparatively little with the arrangements of nature, and the destructive agency of man becomes more and more energetic and unsparing as he advances in civilization." In short, in his opinion, "better fifty years of Cathay than a cycle of Europe."

He took this gloomy view mainly on account of the mischief done by cutting down forests. Man has wrought this destruction not only with his own hand, but through domesticated animals more destructive than wild beasts, sheep, goats, horned cattle, stunting or killing the young shoots of trees. Writing of Tunisia, Mr. Perkins, the principal of Roseworthy College, says: "In so far as young trees and shrubs are concerned, the passage of a flock of goats will do quite as much damage as a bush fire." Mr. Marsh seems to have met a fool in the forest, and it was man; and he found him to be more knave than fool, for man has been, in Mr. Marsh's view, the revolutionary radical confiscating nature's vested interests. "Man," he says, "has too long forgotten that the earth was given to him for usufruct alone, not for consumption, still less for profligate waste." Trees, to his mind, are conservatives of the best kind. They stand in the way, it is true, but they stop excesses, they moderate the climate, they give shelter against the wind, they store the water, prevent inundations, preserve and enrich the soil. "The clear-

ing of the woods," he says, "has in some cases produced within two or three generations effects as blasting as those generally ascribed to geological convulsions, and has laid waste the face of the earth more hopelessly than if it had been buried by a current of lava or a shower of volcanic sand"; and, once more, where forests have been destroyed, he says, "The face of the earth is no longer a sponge but a dust-heap."

The damage done by cutting down trees, and thereby letting loose torrents which wash away the soil, is or was very marked in the south of France, in Dauphiné, Provence and the French Alps. With the felling of trees and the pasturing of sheep on the upper edge of the forest—for sheep break the soil and expose the roots—the higher ground has been laid bare. Rainstorms have in consequence swept off the soil, and the floods have devastated the valleys. The mountain-sides have become deserts, and the valleys have been turned into swamps. "When they destroyed the forest," wrote the great French geographer, Reclus, about thirty years ago, "they also destroyed the very ground on which it stood"; and then he continues: "The devastating action of the streams in the French Alps is a very curious phenomenon in the historical point of view, for it explains why so many of the districts of Syria, Greece, Asia Minor, Africa, and Spain have been forsaken by their inhabitants. The men have disappeared along with the trees; the axe of the woodman, no less than the sword of the conqueror, have put an end to, or transplanted, entire populations." In the latter part of the South African war Sir William Willcocks, skilled in irrigation in Egypt, and now reclaiming Mesopotamia, was brought to South Africa to report upon the possibilities of irrigation there, and in his report dated

November, 1901, he wrote as follows: "Seeing in Basutoland the effect of about thirty years of cultivation and more or less intense habitation convinced me of the fact that another country with steep slopes and thin depth of soil, like Palestine, has been almost completely denuded by hundreds of years of cultivation and intense habits. The Palestine which Joshua conquered and which the children of Israel inhabited was in all probability covered over great part of its area by sufficient earth to provide food for a population a hundred times as dense as that which can be supported to-day." The Scotch geologist, Hugh Miller, again attributed the formation of the Scotch mosses to the cutting down of timber by Roman soldiers. "What had been an overturned forest became in the course of years a deep morass."

In past times there have been voices raised in favor of the forests, but they have been voices crying in the desert which man has made. Here is one. The old chronicler Holinshed, who, lived in the reign of Queen Elizabeth, noted the amount of timber cut down for house building and in order to increase the area for pasturage. "Every small occasion in my time," he writes, "is enough to cut down a great wood"; and in another passage either he himself or one of his collaborators writes that he would wish to live to see four things reformed in England: "The want of discipline in the Church, the covetous dealing of most of our merchants in the preferment of commodities of other countries and hindrance of their own, the holding of fairs and markets upon the Sunday to be abolished and referred to the Wednesdays, and that every man in whatever part of the champaign soil enjoyeth forty acres of land and upwards after that rate, either by free deed, copyhold or fee farm, might plant one acre of

wood or sow the same with oke mast, hazell, beach and sufficient provision be made that it be cherished and kept."

Mr. Marsh seems to have thought that the Old World, and especially the countries which formed the old Roman Empire, had been ruined almost past redemption; and for the beneficent action of man on nature he looked across the seas. "Australia and New Zealand," he writes, "are perhaps the countries from which we have a right to expect the fullest elucidation of these difficult and disputable problems. Here exist greater facilities and stronger motives for the careful study of the topics in question than have ever been found combined in any other theater of European colonization."

His book was first written half a century ago. He was a pessimist evidently, and pessimists exaggerate even more than optimists, for there is nothing more exhilarating and consoling to ourselves than to predict the worst possible consequences from our neighbor's folly. Further, though it may be true that man became more destructive as he became more civilized, it is also true that the destruction has been wrought directly rather by the unscientific than by the scientific man. If we have not grown less destructive since, at any rate we have shown some signs of penitence, and science has come to our aid in the work of reparation. Governments and associations have turned their attention to protecting woodland and reforesting tracts which have been laid bare. The Touring Club of France, for instance, I am told, has taken up the question of the damage done by destruction of trees by men and sheep in Haute Savoie, and it assists reclamation by guidance and by grants. In England, under the auspices of Birmingham University and under the presidency of Sir Oliver Lodge, the Mid-

lands Reafforestation Association is planting the pit mounds and ash quarries of the Black Country with trees which will resist smoke and bad air, alders, willows, poplars, carrying out their work, a report says, under a combination of difficulties not to be found in any other country. Artificial lakes and reservoirs again, such as I shall refer to presently, are being made woodland centers. In most civilized countries nowadays living creatures are to some extent protected, tree planting is encouraged by arbor days, and reserves are formed for forests, for beasts and birds, the survivors of the wild fauna of the earth. Some lands, such as Greece, as I gather from Mr. Perkins's report, are still being denuded of trees, but as a general rule the human conscience is becoming more and more alive to the immorality and the impolicy of wasting the surface of the earth and what lives upon it, and is even beginning to take stock as to whether the minerals beneath the surface are inexhaustible. Therefore I ask you now to consider man as the lord of creation in the nobler sense of the phrase, as transforming geography, but more as a creative than as a destructive agency.

How far has the agency of man altered, and how far is it likely to alter, the surface of the earth, the divisions and boundaries assigned by nature, the climate and the production of the different parts of the globe; and, further, how far, when not actually transforming nature, is human agency giving nature the go-by? It should be borne in mind that science has effected, and is effecting transformation, partly by applying to old processes far more powerful machinery, partly by introducing new processes altogether; and that, as each new force is brought to light, lands and peoples are to a greater or less extent transformed. The world was laid out afresh by coal and steam. A new readjustment is taking place

with the development of water power and oil power. Lands with no coal, but with fine water power or access to oil, are asserting themselves. Oil fuel is prolonging continuous voyages and making coaling stations superfluous. But of necessity it is the earth herself who gives the machinery for altering her own surface. The application of the machinery is contributed by the wit of man.

The surface of the earth consists of land and water. How far has human agency converted water into land or land into water, and how far, without actually transforming land into water and water into land, is it for practical human purposes altering the meaning of land and water as the great geographical divisions? A writer on the Fens of South Lincolnshire has told us: "The Romans, not content with appropriating land all over the world, added to their territory at home by draining lakes and reclaiming marshes." We can instance another great race which, while appropriating land all over the world, has added to it by reclaiming land from water, fresh or salt. The traveler from Great Britain to the most distant of the great British possessions, New Zealand, will find on landing at Wellington a fine street, Lambton Quay, the foreshore of the old beach, seaward of which now rise many of the city's finest buildings on land reclaimed from the sea; and instances of the kind might be indefinitely multiplied. Now the amount of land taken from water by man has been taken more from fresh water than from sea, and, taken in all, the amount is infinitesimal as compared with the total area of land and water; but it has been very considerable in certain small areas of the earth's surface, and from these small areas have come races of men who have profoundly modified the geography and history of the world. This may be illus-

trated from the Netherlands and from Great Britain.

Motley, at the beginning of "The Dutch Republic," writes of the Netherlands: "A region, outcast of ocean and earth, wrested at last from both domains their richest treasures." Napoleon was credited with saying that the Netherlands were a deposit of the Rhine, and the rightful property of him who controlled the sources; and an old writer pronounced that Holland was the gift of the ocean and of the rivers Rhine and Meuse, as Egypt is of the river Nile. The crowning vision of Goethe's *Faust* is that of a free people on a free soil, won from the sea and kept for human habitation by the daily effort of man. Such has been the story of the Netherlands. The Netherlands, as a home for civilized men, were, and are, the result of reclamation, of dykes and polders. The kingdom has a constantly changing area of between 12,000 and 13,000 square miles. Mr. Marsh, in his book, set down the total amount gained to agriculture at the time he wrote "by dyking out the sea and by draining shallow bays and lakes" at some 1,370 square miles, which, he says, was one tenth of the kingdom; at the same time, he estimated that much more had been lost to the sea—something like 2,600 square miles. He writes that there were no important sea dykes before the thirteenth century, and that draining inland lakes did not begin till the fifteenth, when windmills came into use for pumping. In the nineteenth century steam pumps took the place of windmills, science strengthening an already existing process. Between 1815 and 1855, 172 square miles were reclaimed, and this included the Lake of Haarlem, some thirteen miles long by six in breadth, with an area of about seventy-three square miles. This was reclaimed between 1840 and 1853. At the present time, we are told, about forty

square miles are being reclaimed annually in Holland; and meanwhile the Dutch government have in contemplation or in hand a great scheme for draining the Zuyder Zee, which amounts to recovering from the ocean land which was taken by it in historic times at the end of the fourteenth century. The scheme is to be carried out in thirty-three years and is to cost nearly sixteen million pounds. The reclamation is to be effected by an embankment across the mouth of this inland sea over eighteen miles long. The result will be to add 815 square miles of land to the kingdom of the Netherlands, 750 square miles of which will be fertile land, and in addition to create a much-needed freshwater lake with an area of 557 square miles; this lake is to be fed by one of the mouths of the Rhine.

London is partly built on marsh. The part of London where I live, Pimlico, was largely built on piles. A little way north, in the center of fashion, is Belgrave Square, and here a lady whom I used to know had heard her grandfather say that he had shot snipe. Take the City of London in the strict and narrow sense. The names of Moorfields and Fensbury or Finsbury are familiar to those who know the city. Stow, in his survey of London, over three hundred years ago, wrote of "The Moorfield which lieth without the postern called Moor-gate. This field of old time was called the Moor. This fen or moor field stretching from the wall of the city betwixt Bishopsgate and the postern called Cripplegate to Fensbury and to Holywell continued a waste and unprofitable ground a long time." By 1527, he tells us, it was drained "into the course of Walbrook, and so into the Thames, and by these degrees was this fen or moor at length made main and hard ground which before, being overgrown with flags, sedges and rushes, served to no use." It is said that this fen or marsh had come

into being since Roman times. The reclamation which has been carried out in the case of London is typical of what has been done in numerous other cases. As man has become more civilized, he has come down from his earlier home in the uplands, has drained the valley swamps, and on the firm land thus created has planted the streets and houses of great cities.

The Romans had a hand in the draining of Romney Marsh in Sussex, and here nature cooperated with man, just as she has cooperated in the deltas of the great rivers, for the present state of the old Cinque Ports, Rye and Winchelsea, shows how much on this section of the English coast the sea has receded. But the largest reclamation was in East Anglia, where the names of the Fens and the Isle of Ely testify to what the surface once was. "For some of our fens," writes Holinshed, "are well known to be either of ten, twelve, sixteen, twenty or thirty miles in length. . . . Wherein also Elie, the famous isle, standeth, which is seven miles every way, and whereunto there is no access but by three causies." Arthur Young, in 1799, in his "General View of the Agriculture of the County of Lincoln," a copy of which he dedicated to that great friend of Australia, Sir Joseph Banks, who was a Lincolnshire landowner and a keen supporter of reclamation, wrote of the draining which had been carried out in Lincolnshire. "The quantity of land thus added to the kingdom has been great; fens of water, mud, wild fowl, frogs and agues have been converted to rich pasture and arable worth from 20 s. to 40 s. an acre . . . without going back to very remote periods, there can not have been less than 150,000 acres drained and improved on an average from 5 s. an acre to 25 s." 150,000 acres is about 234 square miles, but the amount reclaimed by draining in Lincolnshire in the seventeenth,

eighteenth and nineteenth centuries seems to have been well over 500 square miles. The Fenlands, as a whole, extended into six counties. They were seventy miles in length, from ten to thirty miles broad, and covered an area of from 800 to 1,000 square miles. One estimate I have seen is as high as 1,200 square miles. Mr. Prothero, in his book on "English Farming, Past and Present," tells us that they were "in the seventeenth century a wilderness of bogs, pools and reed shoals—a vast morass from which here and there emerged a few islands of solid earth." In the seventeenth century a Dutch engineer, Vermuyden, was called in to advise, and the result of draining what was called after the peer who contracted for it the Bedford Level, together with subsequent reclamations, was to convert into ploughland and pasture large tracts which, in the words of an old writer, Dugdale, had been "a vast and deep fen, affording little benefit to the realm other than fish or fowl, with overmuch harbor to a rude and almost barbarous sort of lazy and beggarly people." In Lincolnshire there was a district called Holland, and in Norfolk one called Marshland, said to have been drained by, to quote Dugdale again, "those active and industrious people, the Romans."

The Dutch and the English, who thus added to their home lands by reclamation, went far and wide through the world, changing its face as they went. The Dutch, where they planted themselves, planted trees also; and when they came to land like their own Netherlands, again they reclaimed and empoldered. The foreshore of British Guiana, with its canals and sea defences, dating from Dutch times, is now the chief sugar-producing area in the British West Indies. If again in Australia man has been a geographical agency, he

learnt his trade when he was changing the face of his old home in the British Isles.

Instances of reclaiming land from water might be indefinitely multiplied. We might compare the work done by different nations. In Norway, for instance, Reclus wrote that "the agriculturists are now reclaiming every year forty square miles of the marshes and fiords." Miss Semple, who, in the "Influences of Geographic Environment," writes that "between the Elbe and Scheldt" (that is, including with the Netherlands some of North Germany) "more than 2,000 square miles have been reclaimed from river and sea in the past 300 years," tells us also that "the most gigantic dyke system in the world is that of the Hoangho, by which a territory of the size of England is won from the water for cultivation." Or we might take the different objects which have impelled men here and there to dry up water and bank out sea. Agriculture has not been the only object, nor yet reclaiming for town sites. Thus, in order to work the hematite iron mines at Hodbarrow, in Cumberland, an area of 170 acres was, in the years 1900-1904, reclaimed from the sea by a barrier over $1\frac{1}{4}$ miles long, designed by the great firm of marine engineers, Coode and Matthews, who built the Colombo breakwater. The reclaimed land, owing to the subsidence caused by the workings, is now much below the level of the sea. Here is an instance of reclamation not adding to agricultural or pastoral area, but giving mineral wealth, thereby attracting population and enriching a district.

How far has land been drowned by the agency of man? Again the total area is a negligible quantity, but again, relatively to small areas, it has been appreciable, and the indirect effects have been great. The necessities of town life are responsible for new lakes and rivers. Such are the great

reservoirs and aqueducts by which water is being brought to New York from the Catskill Mountains, a work which the writer in the *Times* has described as "hardly second in magnitude and importance to the Panama Canal." In Great Britain cities in search of water supply have ordered houses, churches, fields to be drowned, and small lakes to come into existence. Liverpool created Lake Vyrnwy in Montgomeryshire, with a length of nearly five miles and an area of 1,121 acres. Birmingham is the parent of a similar lake in a wild Radnorshire valley near my old home. The water is not carried for anything like the distance from Mundaring to Kalgoorlie, and on a much greater scale than these little lakes in Wales is the reservoir now being formed in New South Wales by the Burrinjuck dam, on the Murrumbidgee River, which, as I read, is, or will be, forty-one miles long, and cover an area of twenty square miles. If I understand right, in this case, by holding up the waters of a river, a long narrow lake has been or is being called into existence. A still larger volume of water is gathered by the great Assouan dam, which holds up the Nile at the head of the First Cataract, washing, and at times submerging, the old temples on the Island of Philæ in midstream. First completed in 1902, the dam was enlarged and heightened by 1912; and the result of the dam is at the time of high Nile to create a lake of some 65 square miles in area, as well as to fill up the channel of the river for many miles up stream. Illustrations of artificial lakes might be multiplied from irrigation works in India. An official report on the state of Hyderabad, written some years ago, has the following reference to the tanks in the granitic country of that state: "There are no natural lakes, but from the earliest times advantage has been taken of the undulating character of the country to

dam up some low ground or gorge between two hills, above which the drainage of a large area is collected. Such artificial reservoirs are peculiar to the granitic country, and wherever groups of granite hills occur tanks are sure to be found associated with them." Take again the great ship canals. The Suez Canal runs for 100 miles from sea to sea, though for part of its course it runs through water, not through sand. It is constantly growing in depth and width. Its original depth was $26\frac{1}{4}$ feet; it is now, for nine tenths of its length, over 36 feet, and the canal is to be further deepened generally to over 39 feet. Its original width at the bottom was 72 feet; it is now, for most of its course, over 147 feet; in other words, the width has been more than doubled. A writer in the *Times* on the wonderful Panama Canal said: "The locks and the Gatun dam have entailed a far larger displacement of the earth's surface than has ever been attempted by the hand of man in so limited a space." Outside the locks the depth is 45 feet, and the minimum bottom width 300 feet. The official handbook of the Panama Canal says: "It is a lake canal as well as a lock canal, its dominating feature being Gatun Lake, a great body of water covering about 164 square miles." The canal is only fifty miles long from open sea to open sea, from shore line to shore line only forty. But in making it man, the geographical agency, has blocked the waters of a river, the Chagres, by building up a ridge which connects the two lines of hills between which the river flows, this ridge being a dam $1\frac{1}{2}$ miles long, nearly half a mile wide at its base, and rising to 105 feet above sea-level, with the result that a lake has come into existence which is three quarters of the size of the Lake of Geneva, and extends beyond the limits of the Canal zone.

Mr. Marsh, in his book, referred to far

more colossal schemes for turning land into water, such as flooding the African Sahara or cutting a canal from the Mediterranean to the Jordan and this submerging the basin of the Dead Sea, which is below the level of the ocean. The effect of the latter scheme, he estimated, would be to add from 2,000 to 3,000 square miles to the fluid surface of Syria. All that can be said is that the wild-cat schemes of one century often become the domesticated possibilities of the next and the accomplished facts of the third; that the more discovery of new lands passes out of sight the more men's energies and imagination will be concentrated upon developing and altering what is in their keeping; and that, judging from the past, no unscientific man can safely set any limit whatever to the future achievements of science.

But now, given that the proportion of land to water and water to land has not been, and assuming that it will not be, appreciably altered, has water, for practical purposes, encroached on land, or land on water? In many cases water transport has encroached on land transport. The great isthmus canals are an obvious instance; so are the great Canadian canals. The tonnage passing through the locks of the Sault St. Marie is greater than that which is carried through the Suez Canal. Waterways are made where there was dry land, and more often existing inland waterways are converted into sea-going ways. Manchester has become a seaport through its ship canal. The Clyde, in Mr. Vernon Harcourt's words, written in 1895, has been "converted from an insignificant stream into a deep navigable river capable of giving access to ocean-going vessels of large draught up to Glasgow." In 1758 the Clyde at low water at Glasgow was only 15 inches deep, and till 1818 no seagoing vessels came up to Glasgow. In 1895 the

depth at low water was from 17 to 20 feet, and steamers with a maximum draught of $25\frac{1}{2}$ feet could go up to Glasgow. This was the result of dredging, deepening and widening the river, and increasing the tidal flow. The record of the Tyne has been similar. The effect of dredging the Tyne was that in 1895—I quote Mr. Harcourt again—"Between Shields and Newcastle, where formerly steamers of only 3 to 4 feet draught used to ground for hours, there is now a depth of 20 feet throughout at the lowest tides." It is because engineers have artificially improved nature's work on the Clyde and the Tyne that these rivers have become homes of shipbuilding for the whole world. Building training walls on the Seine placed Rouen, seventy-eight miles up the river, high among the seaports of France. The Elbe and the Rhine, the giant rivers Mississippi and St. Lawrence, and many other rivers, have, as we all know, been wonderfully transformed by the hand of the engineer.

But land in turn, in this matter of transport, has encroached upon sea. In old days, when roads were few and bad, when there were no railways, and when ships were small, it was all-important to bring goods by water at all parts as far inland as possible. In England there were numerous flourishing little ports in all the estuaries and up the rivers, which, under modern conditions, have decayed. No one now thinks of Canterbury and Winchester in connection with seaborne traffic; but Mr. Belloc, in "The Old Road," a description of the historical Pilgrims' Way from Winchester to Canterbury, points out how these two old-world cathedral cities took their origin and derived their importance from the fact that each of them, Canterbury in particular, was within easy reach of the coast, where a crossing from France would be made; each on a river—in the

case of Canterbury on the Stour just above the end of the tideway. In the days when the Island of Thanet was really an island, separated from the rest of Kent by an arm of the sea, and when the present insignificant river Stour was, in the words of the historian J. R. Green, "a wide and navigable estuary," Canterbury was a focus to which the merchandise of six Kentish seaports was brought, to pass on inland; it was in effect practically a seaport. Now merchandise, except purely local traffic, comes to a few large ports only, and is carried direct by rail to great distant inland centers. Reclus wrote that bays are constantly losing in comparative importance as the inland ways of rapid communication increase; that, in all countries intersected with railways, indentations in the coast-line have become rather an obstacle than an advantage; and that maritime commerce tends more and more to take for its starting-place ports situated at the end of a peninsula. He argues, in short, that traffic goes on land as far out to sea as possible instead of being brought by water as far inland as possible. He clearly overstated the case, but my contention is that, for human purposes, the coast-line, though the same on the map, has practically been altered by human agency. Ports have been brought to men as much as men to ports. We see before our eyes the process going on of bridging India to Ceylon so as to carry goods and passengers as far by land as possible, and in Ceylon we see the great natural harbor of Trincomalee practically deserted and a wonderful artificial harbor created at the center of population, Colombo.

But let us carry the argument a little further. Great Britain is an island. Unless there is some great convulsion of nature, to all time the Strait of Dover will separate it from the continent of Europe.

Yet we have at this moment a renewal of the scheme for a Channel tunnel, and at this moment men are flying from England to France and France to England. Suppose the Channel tunnel to be made; suppose flying to be improved—and it is improving every day—what will become of the island? What will become of the sea? They will be there and will be shown on the map, but to all human intents and purposes the geography will be changed. The sea will no longer be a barrier, it will no longer be the only high-road from England to France. There will be going to and fro on or in dry land, and going to and fro neither on land nor on sea. Suppose this science of aviation to make great strides, and heavy loads to be carried in the air, what will become of the ports, and what will become of sea-going peoples? The ports will be there, appearing as now on the map, but Birmingham goods will be shipped at Birmingham for foreign parts, and Lithgow will export mineral direct, saying good-bye to the Blue Mountains and even to Sydney harbor.

Now, in saying this I may well be told by my scientific colleagues that it is all very well as a pretty piece of fooling, but that it is not business. I say it as an unscientific man with a profound belief in the limitless possibilities of science. How long is it since it was an axiom that, as a lump of iron sinks in water, a ship made of iron could not possibly float? Is it fatuous to contemplate that the conquest of the air, which is now beginning, will make it a highway for commercial purposes? We have aeroplanes already which settle on the water and rise again; we are following on the track of the gulls which we wonder at far away in the limitless waste of ocean. A century and a half ago the great Edmund Burke ridiculed the idea of representatives of the old North American colonies sitting in the Imperial

Parliament; he spoke of any such scheme as fighting with nature and conquering the order of Providence; he took the distance, the time which would be involved—six weeks from the present United States to London. If any one had told him that what is happening now through the applied forces of science might happen, he would have called him a madman. Men think in years, or at most in lifetimes; they ought sometimes to think in centuries. I believe in Reclus's words, "All man has hitherto done is a trifle in comparison with what he will be able to effect in future." Science is like a woman. She says no again and again, but means yes in the end.

In dealing with land and water I have touched upon natural divisions and natural boundaries, which are one of the provinces of geography. Flying gives the go-by to all natural divisions and boundaries, even the sea; but let us come down to the earth. Isthmuses are natural divisions between seas; the ship canals cut them and link the seas—the canal through the Isthmus of Corinth, the canal which cuts the Isthmus of Perekop between the Crimea and the mainland of Russia, the Baltic Canal, the Suez Canal, the Panama Canal. The Suez Canal, it will be noted, though not such a wonderful feat as the Panama Canal, is more important from a geographical point of view, in that an open cut has been made from sea to sea without necessity for locks, which surmount the land barrier but more or less leave it standing. Inland, what are natural divisions? Mountains, forests, deserts, and, to some extent, rivers. Take mountains. "High, massive mountain systems," writes Miss Semple, "present the most effective barriers which man meets on the land surface of the earth." But are the Rocky Mountains, for instance, boundaries, dividing lines, to anything like the extent that they were now that railways go through and

over them, carrying hundreds of human beings back and fore day by day? On what terms did British Columbia join the Dominion of Canada? That the natural barrier between them should be pierced by the railway. Take the Alps. The canton Ticino, running down to Lake Maggiore, is politically in Switzerland; it is wholly on the southern side of the Alps. Is not the position entirely changed by the St. Gothard tunnel, running from Swiss territory into Swiss territory on either side of the mountains?

If, in the Bible language, it requires faith to remove mountains, it is not wholly so with other natural boundaries. Forests were, in old days, very real natural dividing lines. They were so in England, as in our own day they have been in Central Africa. Between forty and fifty years ago, in his "Historical Maps of England," Professor C. H. Pearson, whose name is well known and honored in Australia, laid down that England was settled from east and west, because over against Gaul were heavy woods, greater barriers than the sea. Kent was cut off from Central England by the Andred Weald, said to have been, in King Alfred's time, 120 miles long and 30 broad. Here are Professor Pearson's words: "The axe of the woodman clearing away the forests, the labor of nameless generations reclaiming the fringes of the fens or making their islands habitable, have gradually transformed England into one country, inhabited by one people. But the early influences of the woods and fens are to isolate and divide." Thus the cutting down of trees is sometimes a good, not an evil, and there are some natural boundaries which man can wholly obliterate.

Can the same be said of deserts? They can certainly be pierced, like isthmuses and like mountains. The Australian desert is a natural division between western and

south Australia. The desert will be there, at any rate for many a long day after the transcontinental railway has been finished, but will it be, in anything like the same sense as before, a barrier placed by nature and respected by man? Nor do railways end with simply giving continuous communication, except when they are in tunnels. As we all know, if population is available, they bring in their train development of the land through which they pass. Are these deserts of the earth always going to remain "deserts idle"? Is man going to obliterate them? In the days to come, will the desert rejoice and blossom as the rose? What will dry farming and what will afforestation have to say? In the evidence taken in Australia by the Dominions Royal Commission, the Commissioner for Irrigation in New South Wales tells us that "the dry farming areas are carried out westward into what are regarded as arid lands every year," and that, in his opinion, "we are merely on the fringe of dry farming" in Australia. A book has lately been published entitled "The Conquest of the Desert." The writer, Dr. Macdonald, deals with the Kalahari Desert in South Africa, which he knows well, and for the conquest of the desert he lays down that three things are essential—population, conservation and afforestation. He points out in words which might have been embodied in Mr. Marsh's book, how the desert zone has advanced through the reckless cutting of trees, and how it can be flung back again by tree barriers to the sand dunes. By conservation he means the system of dry farming so successful in the United States of America, which preserves the moisture in the soil and makes the desert produce fine crops of durum wheat without a drop of rain falling upon it from seedtime to harvest, and he addresses his book "to the million settlers of to-morrow upon the dry and desert lands

of South Africa." If the settlers come, he holds that the agency of man, tree-planting, ploughing and harrowing the soil, will drive back and kill out the desert. The effect of tree-planting in arresting the sand dunes and reclaiming desert has been very marked in the Landes of Gascony. Here, I gather from Mr. Perkins's report, are some 3,600 square miles of sandy waste, more than half of which had, as far back as 1882, been converted into forest land, planted mainly with maritime pines.

What, again, will irrigation have to say to the deserts? Irrigation, whether from underground or from overground waters, has already changed the face of the earth, and as the years go on, as knowledge grows and wisdom, must inevitably change it more and more. I read of underground waters in the Kalahari. I read of them too in the Libyan Desert. In the *Geographical Journal* for 1902 it is stated that at that date nearly 22,000 square miles in the Algerian Sahara had been reclaimed with water from artesian wells. What artesian and sub-artesian water has done for Australia you all know. If it is not so much available for agricultural purposes, it has enabled flocks and herds to live and thrive in what would be otherwise arid areas. Professor Gregory, Mr. Gibbons Cox, and others have written on this subject with expert knowledge; evidence has been collected and published by the Dominions Royal Commission, but I must leave to more learned and more controversial men than I am to discuss whether the supplies are plutonic or meteoric, and how far in this matter you are living on your capital.

If we turn to irrigation from overground waters, I hesitate to take illustrations from Australia, because my theme is the blotting out of the desert, and most of the Australian lands which are being irrigated from rivers, and made scenes of closer settlement,

would be libeled if classed as desert. Mr. Elwood Mead told the Royal Commission that the state irrigation works in Victoria, already completed or in process of construction, can irrigate over 600 square miles, and that, if the whole water supply of the state were utilized, more like 6,000 square miles might be irrigated. The Burrinjuck scheme in New South Wales will irrigate, in the first instance, not far short of 500 square miles, but may eventually be made available for six times that area. If we turn to irrigation works in India, it appears from the second edition of Mr. Buckley's work on the subject, published in 1905, that one canal system alone, that of the Chenab in the Punjab, had, to quote his words, turned "some two million acres of wilderness (over 3,000 square miles) into sheets of luxuriant crops." "Before the construction of the canal," he writes, "it was almost entirely waste, with an extremely small population, which was mostly nomad. Some portion of the country was wooded with jungle trees, some was covered with small scrub camel thorn, and large tracts were absolutely bare, producing only on occasions a brilliant mirage of unbounded sheets of fictitious water." The Chenab irrigation works have provided for more than a million of human beings; and, taking the whole of India, the Irrigation Commission of 1901-03 estimated that the amount of irrigated land at that date was 68,750 square miles; in other words, a considerably larger area than England and Wales. Sir William Willcocks is now reclaiming the delta of the Euphrates and Tigris. The area is given as nearly 19,000 square miles, and it is described as about two thirds desert and one third freshwater swamp. Over 4,000 square miles of the Gezireh Plain, between the Blue and the White Nile, are about to be reclaimed, mainly for cotton cultivation,

by constructing a dam on the Blue Nile at Sennaar and cutting a canal 100 miles long which, if I understand right, will join the White Nile thirty miles south of Khartoum.

With the advance of science, with the growing pressure of population on the surface of the earth, forcing on reclamation as a necessity for life, is it too much to contemplate that human agency in the coming time will largely obliterate the deserts which now appear on our maps? It is for the young peoples of the British Empire to take a lead in—to quote a phrase from Lord Durham's great report—"the war with the wilderness," and the great feat of carrying water for 350 miles to Kalgoorlie, in the very heart of the wilderness, shows that Australians are second to none in the ranks of this war.

It is a commonplace that rivers do not make good boundaries because they are easy to cross by boat or bridge. Pascal says of them that they are "*des chemins qui marchent*" (roads that move), and we have seen how these roads have been and are being improved by man. "Rivers unite," says Miss Semple; and again, "Rivers may serve as political lines of demarcation, and therefore fix political frontiers, but they can never take the place of natural boundaries. All the same, in old times, at any rate, rivers were very appreciable dividing lines, and when you get back to something like barbarism, that is to say in time of war, it is realized how powerful a barrier is a river. Taking, then, rivers as in some sort natural boundaries, or treating them only as political boundaries, the point which I wish to emphasize is that they are becoming boundaries which, with modern scientific appliances, may be shifted at the will of man. In the days to come the diversion of rivers may become the diversion of a new race of despotic rulers with infinitely greater

power to carry out their will or their whim than the Pharaohs possessed when they built the Pyramids. You in Australia know how thorny a question is that of the control of the Murray and its tributaries. There are waterways conventions between Canada and the United States. Security for the headwaters of the Nile was, and is, a prime necessity for the Sudan and Egypt. The Euphrates is being turned from one channel into another. What infinite possibilities of political and geographical complications does man's growing control over the flow of rivers present!

Thus I have given you four kinds of barriers or divisions set by nature upon the face of the earth—mountains, forests, deserts, rivers. The first, the mountains, man can not remove, but he can and he does go through them to save the trouble and difficulty of going over them. The second, the forests, he has largely cleared away altogether. The third, the deserts, he is beginning to treat like the forests. The fourth, the rivers, he is beginning to shift when it suits his purpose and to regulate their flow at will.

I turn to climate. Climates are hot or cold, wet or dry, healthy or unhealthy. Here our old friends the trees have much to say. Climates beyond dispute become at once hotter and colder when trees have been cut down and the face of the earth has been laid bare; they become dryer or moister according as trees are destroyed or trees are planted and hold the moisture; the cutting and planting of timber affects either one way or the other the health of a district. The tilling of the soil modifies the climate. This has been the case, according to general opinion, in the northwest of Canada, though I have not been able to secure any official statistics on the subject. In winter time broken or ploughed land does not hold the snow and ice to the same

extent as the unbroken surface of the prairie; on the other hand, it is more retentive at once of moisture and of the rays of the sun. The result is that the wheat zone has moved further north, and that the intervention of man has, at any rate for agricultural purposes, made the climate of the great Canadian northwest perceptibly more favorable than it was. In Lord Strathcona's view, there was some change even before the settlers came in, as soon as the rails and telegraph lines of the Canadian Pacific Railway were laid. He told me that in carrying the line across a desert belt it was found that, within measurable distance of the rail and the telegraph line, there was a distinct increase of dew and moisture. I must leave it to men of science to say whether this was the result of some electrical or other force, or whether what was observed was due simply to a wet cycle coinciding with the laying of the rails and the erection of the wires. I am told that it is probably a coincidence of this kind, which accounts for the fact that in the neighborhood of the Assouan dam there is at present a small annual rainfall, whereas in past years the locality was rainless. Reference has already been made to the effect of cultivation in the Kalahari Desert in increasing the storage of moisture in the soil. But it is when we come to the division between healthy and unhealthy climates that the effect of science upon climate is most clearly seen. The great researches of Ross, Manson and many other men of science, British and foreign alike, who have traced malaria and yellow fever back to the mosquito, and assured the prevention and gradual extirpation of tropical diseases, bid fair to revolutionize climatic control. Note, however, that in our penitent desire to preserve the wild fauna of the earth we are also establishing preserves for mosquitoes, trypanosomes and the tsetse fly.

Nowhere have the triumphs of medical science been more conspicuous than where engineers have performed their greatest feats. De Lesseps decided that Ismailia should be the headquarters of the Suez Canal, but the prevalence of malaria made it necessary to transfer the headquarters to Port Said. In 1886 there were 2,300 cases of malaria at Ismailia; in 1900 almost exactly the same number. In 1901 Sir Ronald Ross was called in to advise; in 1906 there were no fresh cases, and the malaria has been stamped out. De Lessep's attempt to construct the Panama Canal was defeated largely, if not mainly, by the frightful death-rate among the laborers; 50,000 lives are said to have been lost, the result of malaria and yellow fever. When the Americans took up the enterprise they started with sending in doctors and sanitary experts, and the result of splendid medical skill and sanitary administration was that malaria and yellow fever were practically killed out. The Panama Canal is a glorious creation of medical as well as of engineering science, and this change of climate has been mainly due to reclamation of pools and swamps, and to cutting down bush, for even the virtuous trees, under some conditions, conduce to malaria. Man is a geographical agency, and in no respect more than in the effect of his handiwork on climate, for climate determines products, human and others. Science is deciding that animal pests shall be extirpated in the tropics, and that there shall be no climates which shall be barred to white men on the ground of danger of infection from tropical diseases.

If we turn to products, it is almost superfluous to give illustrations of the changes wrought by man. As the incoming white man has in many places supplanted the colored aboriginal, so the plants and the living creatures brought in by the white man have in many cases, as you know well,

ousted the flora and fauna of the soil. Here is one well-known illustration of the immigration of plants. Charles Darwin, on the voyage of the *Beagle*, visited the island of St. Helena in the year 1836. He wrote "that the number of plants now found on the island is 746, and that out of these fifty-two alone are indigenous species." The immigrants, he said, had been imported mainly from England, but some from Australia, and, he continued, "the many imported species must have destroyed some of the native kinds, and it is only on the highest and steepest ridges that the indigenous flora is now predominant."

Set yourselves to write a geography of Australia as Australia was when first made known to Europe, and compare it with a geography now. Suppose Australia to have been fully discovered when Europeans first reached it, but consider the surface then and the surface now, and the living things upon the surface then and now. Will not man have been found to be a geographical agency? How much waste land, how many fringes of desert have been reclaimed? The wilderness has become pasture land, and pasture land, in turn, is being converted into arable. The Blue Mountains, which barred the way to the interior, are now a health resort. Let us see what Sir Joseph Banks wrote after his visit to Australia on Captain Cook's first voyage in 1770. He has a chapter headed "Some Account of that part of New Holland now called New South Wales." New Holland he thought "in every respect the most barren country I have seen"; "the fertile soil bears no kind of proportion to that which seems by nature doomed to everlasting barrenness." "In the whole length of coast which we sailed along there was a very unusual sameness to be observed in the face of the country. Barren it may justly be called, and

in a very high degree, so far, at least, as we saw." It is true that he only saw the land by the sea, but it was the richer eastern side of Australia, the outer edge of New South Wales and Queensland. What animals did he find in Australia? He "saw an animal as large as a greyhound, of a mouse color, and very swift." "He was not only like a greyhound in size and running, but had a tail as long as any greyhound's. What to liken him to I could not tell." Banks had a greyhound with him, which chased this animal. "We observed, much to our surprise, that, instead of going upon all fours, this animal went only on two legs, making vast bounds." He found out that the natives called it kangaroo, and it was "as large as a middling lamb." He found "this immense tract of land," which he said was considerably larger than all Europe, "thinly inhabited, even to admiration, at least that part of it that we saw." He noted the Indians, as he called them, whom he thought "a very pusillanimous people." They "seemed to have no idea of traffic"; they had "a wooden weapon made like a short scimitar." Suppose a new Sir Joseph Banks came down from the planet Mars to visit Australia at this moment, what account would he give of it in a geographical handbook for the children of Mars? He would modify the views about barrenness, if he saw the cornfields and flocks and herds; if he visited Adelaide, he would change his opinion as to scanty population, though not so, perhaps, if he went to the back blocks. He would record that the population was almost entirely white, apparently akin to a certain race in the North Sea, from which, by tradition, they had come; that their worst enemies could not call them pusillanimous; that they had some ideas of traffic, and used other weapons than a wooden scimitar; and he would probably give the

first place in animal life not to the animal like a greyhound on two legs; but to the middling lamb, or perhaps to the ubiquitous rabbit. Australia is the same island continent that it always was; there are the same indentations of coast, the same mountains and rivers, but the face of the land is different. In past years there was no town, and the country was wilderness; on the surface of the wilderness many of the living things were different; and from under the earth has come water and mineral, the existence of which was not suspected. A century hence it will be different again, and I want to see sets of maps illustrating more clearly than is now the case the changes which successive generations of men have made and are making in the face of Australia and of the whole earth.

More than half a century ago Buckle, in his "History of Civilization," wrote: "Formerly the richest countries were those in which nature was most bountiful; now the richest countries are those in which man is most active. For in our age of the world, if nature is parsimonious we know how to compensate her deficiencies. If a river is difficult to navigate, or a country difficult to traverse, an engineer can correct the error and remedy the evil. If we have no rivers we make canals; if we have no natural harbors we make artificial ones." These words have a double force at the present day and in the present surroundings, for nowhere has man been more active as a geographical agency than in Australia; and not inside Australia only, but also in regard to the relations of Australia to the outside world.

An island continent Australia is still, and always will be, on the maps. It always will be the same number of miles distant from other lands; but will these maps represent practical everyday facts? What do miles mean when it takes a perpetually dimin-

ishing time to cover them? Is it not truer to facts to measure distances, as do Swiss guides, in Stunden (hours)? What, once more, will an island continent mean if the sea is to be overlooked and overflowed? The tendency is for the world to become one; and we know perfectly well that, as far as distance is concerned, for practical purposes the geographical position of Australia has changed through the agency of scientific man. If you come to think of it, what geography has been more concerned with than anything else, directly or indirectly, is distance. It is the knowledge of other places not at our actual door that we teach in geography, how to get there, what to find when we get there, and so forth. The greatest revolution that is being worked in human life is the elimination of distance, and this elimination is going on apace. It is entering into every phase of public and private life, and is changing it more and more. The most difficult and dangerous of all Imperial problems at this moment is the color problem, and this has been entirely created by human agency, scientific agency, bringing the lands of the colored and the white men closer together. Year after year, because distance is being diminished, coming and going of men and of products is multiplying; steadily and surely the world is becoming one continent. This is what I want geographers to note and the peoples to learn. Geographers have recorded what the world is according to nature. I want them to note and teach others to note how under an all-wise Providence it is being subdued, replenished, recast and contracted by man.

CHARLES P. LUCAS

PROFESSOR HUGO KRONECKER

HUGO KRONECKER, for the last thirty years professor of physiology at the University of Berne, Switzerland, died June 6. Although